Common forms of biomass

Generally material derived from any animal or plant

- Forestry residues and co-products
- Other clean woody material – joinery waste and arboriculture waste
- Agricultural by-products, e.g. straw
- Energy crops – Short Rotation Coppice (SRC), e.g., willow, miscanthus,
## Common fuels and their relative costs

<table>
<thead>
<tr>
<th>Fuel and Price</th>
<th>Typical Delivered Price</th>
<th>Fuel Heating Value (HHV)</th>
<th>Typical Combustor Efficiency (%)</th>
<th>Cost per Unit Energy ($/GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordwood, 30% moisture, Delivered</td>
<td>$150 per cord</td>
<td>14.1 MJ/kg</td>
<td>60</td>
<td>13.36</td>
</tr>
<tr>
<td>Clean, Green Wood Chips, 40% moisture</td>
<td>$50 per ton</td>
<td>12.1 MJ/kg</td>
<td>80</td>
<td>5.73</td>
</tr>
<tr>
<td>Dried Wood Chips, 20% moisture</td>
<td>$70 per ton</td>
<td>16.1 MJ/kg</td>
<td>80</td>
<td>5.72</td>
</tr>
<tr>
<td>Premium Hardwood Pellets, 5%</td>
<td>$6 per 22 kg bag</td>
<td>18.1 MJ/kg</td>
<td>80</td>
<td>18.83</td>
</tr>
<tr>
<td>Switchgrass Pellets, 5% moisture</td>
<td>$6 per 22kg bag</td>
<td>17.2 MJ/kg</td>
<td>80</td>
<td>19.82</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>$12 per 1000 cf</td>
<td>38.3 MJ/m3</td>
<td>80</td>
<td>15.35</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>$3.50 per gallon</td>
<td>36.4 MJ/litre</td>
<td>80</td>
<td>31.89</td>
</tr>
<tr>
<td>Coal</td>
<td>$110 per short ton</td>
<td>28 MJ/kg</td>
<td>75</td>
<td>5.12</td>
</tr>
<tr>
<td>Electricity (resistance heat)</td>
<td>$0.12 per kWh</td>
<td>3.6 MJ/kwh</td>
<td>100</td>
<td>33.33</td>
</tr>
</tbody>
</table>

### Willow cash flow diagram

(Buchholz and Volk, 2011)
Willow economics

- Yield of 5 odt acre⁻¹ yr⁻¹ (11.3 odt ha⁻¹ yr⁻¹)
- $30/ton delivered
- Has an IRR of 5.3%
- With the following cost structure

![Cost structure diagram](image)

Source: Buchholz and Volk 2011

Key factors limiting more use

- Technology (production costs)
  - Logging residues are a less costly biomass source from conventional forests (except for mill residues).
  - Cost-effective production with other higher valued forest products (sawlogs, pulping chips)
- Demand (markets)
  - Some market niches for biomass/bioenergy exist
  - No CO₂ market
- Alternative fuel sources (competition)
  - Prices of gas and coal
  - Agricultural crops and crop residues, solar, wind, and hydro energy, among others
  - Other uses of forest resources (pulp markets)
Wood heating systems for institutions

- Typically two to three times the capital costs of oil heating systems
  - complex fuel handling and fuel storage requirements
  - more operation and maintenance (O & M) costs.
- It's all about fuel costs that allows wood heating systems to compete in the marketplace
- It’s a low-cost fuel ($ per million Btu)

Planning and Analysis

- Size of operation
- Amount of energy consumed
- Type of current fuel used
- Engineering assessment and a thorough cost analysis
  - With and without project
  - Budget
  - Cash flow analysis (method used)
  - Assumptions
Life Cycle Analysis

• Most accurate
  – accounts for time value of money
• All project costs and all project benefits are analyzed for each year of the project’s entire life
  – Cost of financing
  – Maintenance, repair, and replacement
  – Costs of the competing options
• Assumptions
  – Discount rates
  – Expected fuel price changes
• Sensitivity analysis

Penns valley school example

<table>
<thead>
<tr>
<th>Total project cost</th>
<th>$2,804,694</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost after grants and subsidies</td>
<td>$1,483,049</td>
</tr>
<tr>
<td>Fuel: 61,700 gallons</td>
<td></td>
</tr>
<tr>
<td>Fuel Oil Price</td>
<td>$3.50</td>
</tr>
<tr>
<td>Wood Chips 1,200 tons</td>
<td></td>
</tr>
<tr>
<td>Wood Chip Price $40.00/ton</td>
<td></td>
</tr>
<tr>
<td>BTU ratio (net basis)</td>
<td>86%</td>
</tr>
<tr>
<td>General Inflation</td>
<td>3%</td>
</tr>
<tr>
<td>Fuel Oil Inflation</td>
<td>5%</td>
</tr>
<tr>
<td>Wood Chip Inflation</td>
<td>3%</td>
</tr>
<tr>
<td>Operating and maintenance</td>
<td>$3,000/year</td>
</tr>
</tbody>
</table>

Other assumptions:
• 30 year life at 4% discount rate
• No repairs
• Payment over 20 years
Financial analysis

Pay Back

<table>
<thead>
<tr>
<th></th>
<th>Fuel Oil Cost Only</th>
<th>Wood Chip System</th>
<th>Annual Savings</th>
<th>Capital cost</th>
<th>Simple Payback (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/grants</td>
<td>$215,950</td>
<td>$74,513</td>
<td>$141,437</td>
<td>$1,483,049</td>
<td>10.5</td>
</tr>
<tr>
<td>w/out grants</td>
<td>$215,950</td>
<td>$74,513</td>
<td>$141,437</td>
<td>$2,804,694</td>
<td>19.8</td>
</tr>
</tbody>
</table>

Net present value and rate of return

<table>
<thead>
<tr>
<th>30 yr NPV</th>
<th>NPV Fuel Oil</th>
<th>NPV Wood Chip Fuel</th>
<th>NPV Cash flow of savings</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>4% with grants</td>
<td>-($7,181,104)</td>
<td>-($3,574,099)</td>
<td>$3,607,004</td>
<td>15%</td>
</tr>
<tr>
<td>4% without grants</td>
<td>-($7,181,104)</td>
<td>-($4,870,328)</td>
<td>$2,310,776</td>
<td>8%</td>
</tr>
</tbody>
</table>

Other factors to consider

- Storage and supply issues
  - e.g., traffic
- System management issues
  - Repairs
  - Automation
- Tax incentives
  - Depreciation
  - Renewable energy credits
- Environmental benefits or costs
  - Water, nutrients, biodiversity
- Carbon offsets?
‘Debt then dividend’ accounting framework

Benefits

• For landowners:
  – Revenue from biomass sales and carbon credits
  – Savings on forest management expenses
  – Improve forest health?
  – Reduction in the risk of wildfire and disease/pest outbreaks

• For society:
  – Local jobs and economic development
  – Global warming - positive impact, if sustainable
How Can Biomass Be More Competitive?

• Reduce fuel costs by improving the efficiency in growing, procuring, transporting, and processing forest biomass

• Reduce non-fuel costs through improving efficiency in energy conversion (from biomass to secondary energy)

• Tax CO₂ emissions or provide incentives/credits for carbon displacement